BONAIRE ESTAFETTE EXPEDITIE, AN INVENTORY OF THE TERRESTRIAL INVERTEBRATES OF BONAIRE

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This special volume contains 21 papers on the invertebrates of Bonaire, and some other Dutch Caribbean islands. Most papers are based on material collected during the Bonaire Estafette Expeditie held in 2022-2023. In this introduction we give background information on the climate, geography and habitats of Bonaire and other Dutch Caribbean islands. We present information on the current state of knowledge on the terrestrial invertebrates of Aruba, Bonaire and Curaçao and give a description of the Bonaire Estafette Expeditie.

THE DUTCH CARIBBEAN ISLANDS

The Dutch Caribbean islands formerly known as the Dutch Antilles consist of six main islands, Aruba, Bonaire, Curaçao (the ABC islands, which are close to the coast of Venezuela) and Saba, Sint Eustatius and Sint Maarten (the SSS islands) which lie on the eastern border of the Caribbean Sea (fig. 1). Aruba, Curaçao and Sint Maarten are independent countries within the Kingdom of the Netherlands. The other three islands are special municipalities of the Netherlands. The islands are surrounded by deep, clear seawater, and, with the exception of Aruba, have never been connected to the mainland. The ABC islands are situated in the Southern Caribbean Dry Zone, a climate zone characterised by a semi-arid tropical marine climate

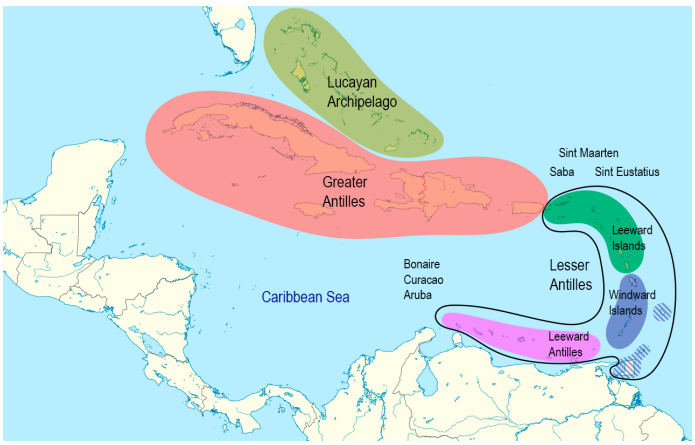

Figure 1. The Caribbean region, with the location of the six main Dutch Caribbean islands. The Caribbean region includes both the island archipelagos and parts of the mainland bordering the Caribbean Sea, including the Lucayan Archipelago which strictly speaking does not border the Caribbean Sea. The term West Indies, which in the Netherlands is less often used, refers more strictly to the islands bordering the Caribbean Sea, so not including adjacent mainland. But both terms are interchangeable and often it is not clear which definition is used. The Leeward Islands and the Windward Islands together are in Dutch referred to as the Bovenwindse Eilanden and contain Saba, Sint Eustatius and Sint Maarten. The Leeward Antilles are in Dutch referred to as the Benedenwindse Eilanden and contain Aruba, Bonaire and Curaçao.

(Hoetjes 2010). This climate features distinct wet and dry seasons, with a relatively constant temperature throughout the year. The warmest month is August (about 29 °C on average), while January is the coolest (26 °C).

The ABC islands lie on the southern edge of the Atlantic hurricane region, where the likelihood of hurricanes is minimal, occurring roughly once every 100 years. The SSS islands fall within the Atlantic hurricane belt and have a wetter tropical marine climate with a longer rainy season. Similar to the ABC islands, the temperature remains relatively stable throughout the year. The Atlantic hurricane season typically lasts from June through November but can start earlier and extend beyond that period. Unlike the ABC islands, the SSS islands experience hurricane conditions approximately every 4-5 years. The ABC islands are relatively flat compared with the SSS islands, primarily due to the latter's more recent volcanic origin. Furthermore, the vegetation on the ABC islands is largely similar, whereas the SSS islands exhibit greater variation between the islands. Most islands are characterised by vegetation adapted to withstand droughts, with dry tropical deciduous forest being the dominant type in undisturbed areas. However, Saba, with its higher elevation and increased rainfall, has a well-developed tropical forest (Hoetjes 2010).

FAUNA OF THE ABC ISLANDS

Without doubt the highest value of the ABC islands for biodiversity is found in its marine ecosystems (Debrot et al. 2018), which are also of economic importance for fishery and tourism (diving). Most research on biodiversity has been focussed on marine taxa. The terrestrial fauna of the ABC islands is interesting and contains several groups not found in the European part of the Netherlands (fig. 2-3) but received relatively little attention with only birds, bats, amphibians and reptiles having been studied in some detail. Most other groups, including all insects, remained largely unstudied and even for relatively popular groups such as butterflies and dragonflies information on distribution is very limited (fig. 4-5). This dearth of entomological publications was already noted by Geijskes & Wagenaar Hummelinck (1951) who remarked that only few have occupied themselves with the entomology of the Antilles.

The work of the Natuurwetenschappelijke Studiekring voor Suriname en de Nederlandse Antillen (Foundation for Scientific Research in Surinam and the Netherlands Antilles, established in 1945) and the Natuurwetenschappelijke Werkgroep Nederlandse Antillen (Natural Science Study Group of the Netherlands Antilles, established in 1948) (Wagenaar Hummelinck 1968) resulted in a number of publications of relevance to the entomology of the ABC islands which were mostly


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Figure 2-3. Bonaire is home to several groups not found in the European part of the Netherlands, 2. sun spiders (order Solifugae), 3. Mantidflies (Mantispidae, order Neuroptera). Photos Roy Kleukers.

published in Studies on the fauna of Curaçao and other Caribbean islands (1953-1988) and (Nieuwe) West-Indische Gids ((New) West-Indian Guide). Of these, a series of publications by R.H. Cobben on the Heteroptera fauna of the Dutch Caribbean islands (with various co-authors) are the most extensive. He was also the only entomologist conducting dedicated entomological fieldwork on all six main islands of the Dutch Caribbean resulting in a large collection of true bugs, cicadas and beetles. This material is currently stored at Naturalis Biodiversity Center in Leiden (the Netherlands) but has remained mostly unstudied. The only other person who made extensive entomological collections on the Dutch Caribbean islands was P. Wagenaar Hummelinck who made nine trips to the Dutch Caribbean islands. However, he did not focus on entomology, having a broad interest in zoology, archaeology and geology. Most of his material, part of which is kept in alcohol jars, is housed at Naturalis Biodiversity Center but remains unstudied and unpublished. He did facilitate future work on his material by producing a catalogue of his collection sites (Wagenaar Hummelinck 1981).

Much of what we know on the insects and molluscs of the ABC islands is scattered throughout a large number of publications, many of which are faunistic papers or revisions in which the ABC islands are not the main focus. The information contained in all these papers is summarised in the Dutch Caribbean Species Register (Dutch-caribbeanspecies.org) where information can be found on the presence of species on the different Dutch Caribbean islands. This includes references to the publications which makes the DCSR an important gateway to knowledge on the biodiversity of the islands.

There is no proper overview of entomological and malacological collections from the ABC islands housed at Naturalis. However, it is clear that these collections are relatively small and that most material is in need of re-identification. Despite the relatively small amount of material these collections are likely to be the most important historical reference available for the ABC islands and warrant further study and digitalisation.

With the notable exception of papers on arachnids (Bonaire) (Crews et al. 2019), beetles (Colijn et al. 2019), dragonflies (Paulson et al. 2014) and molluscs (Hovestadt & Van Leeuwen 2017) very few recent overviews of invertebrates for the ABC islands are available. Colijn et al. (2019) does not only provide an extensive overview of the beetles known from the Dutch Caribbean islands but also gives an extensive summary of the climate and vegetation of all islands and includes biographies of all beetle collectors and is therefore a valuable resource of information also for those working on other insect groups.

Figure 4-5. Even popular groups as butterflies and dragonflies have been poorly studied on Bonaire, 4. *Leptotes cassius,* 5. *Orthemis* spec. Photos Jan-Joost Mekkes.

IDENTIFICATION

The study of the terrestrial fauna of the Dutch Caribbean islands is strongly hampered by the lack of easily accessible literature on identification. For the vascular plants a good and attractive book (Arnoldo & Proosdij 2012) has been published but this publication is out of print and is difficult to find second-hand. For birds, amphibians and reptiles and butterflies field guides are available although the latter two are in need of updating (Van Buurt 2001, Debrot & Miller 2004, De Boer et al. 2012, Wells et al. 2017). For all other groups information on identification is scattered among a large number of, often old, publications due to which identification is only possible by experts. In order to make identification by non-experts possible, Naturalis Biodiversity Center, Observation.org and the Dutch Caribbean Nature Alliance created an image recognition tool for the fauna and flora of all Dutch Caribbean islands which is accessible through Observation.org and the app ObsIdentify. This image recognition model includes most of the mammals, birds, amphibians and reptiles listed on the Dutch Caribbean Species Register from the island. However, less than half of the insects and only a fraction of the other invertebrates known to occur on the island are included due to limited availability of images needed to train the model. The model is furthermore limited by the fact that many, often common, species have simply never officially been recorded on the islands and were therefore not included in the model. Despite these limitations the image recognition model already strongly contributes to the identification of records from the ABC islands submitted to Observation.org. The model is updated regularly and it is expected that the taxonomic coverage will increase strongly in the next few years.

CLIMATE, HISTORY AND VEGETATION

Figure 6 shows a map of Bonaire in which the island is divided into 12 landscape types reflecting the biophysical, cultural and aesthetic values. This division matches very well with the differences easily observed in the field. For a detailed description of these landscape types we refer to Verweij et al. (2020).

With 288 km² Bonaire is only slightly bigger than the Dutch Wadden island Ameland. It consists of volcanic rocks partly covered with marine sediments and limestone deposits (Wagenaar Hummelinck 1940, Hippolyte & Mann 2011, Schmutz et al. 2017). The island is relatively flat and low, especially in the southeast and south of the islands where large expanses of land consist of salt pans. The northern part contains several elevated areas which can roughly be divided into two regions. The first is the northwestern hill region in figure 6 and consists of a number of low mountains, which form the central part of the Washington Slagbaai National Park (WSNP). The second is the calcareous ancient forest plateau, which consists of a large ridge running from north of Kralendijk to the southwestern corner of the WSNP. The 240 m high Brandaris in the center of the WSNP is the highest point in Bonaire.

Bonaire is part of the Southern Caribbean Dry Zone which also includes Aruba and Curaçao, as well as adjacent coastal areas of Venezuela, and has a semi-arid tropical climate. With daily temperatures of 27-30 ºC the island experiences relatively high temperatures with little seasonal variation (less than 1.5 ºC) and daily variation (less than 6 ºC). On average the island receives 520 mm rain a year with 60 % falling in the four wet months (October to January). The ABC islands lie outside the hurricane belt. However, they experience a near constant eastern wind. Due to this nearly all sites for snorkelling and diving on Bonaire are found on the west coast. The east coast mainly consists of relatively steep cliffs.

At present 312 vascular plants are listed as occurring on Bonaire (speciesdistribution.dcbd.nl), which includes a few dozen of introduced species. Species rich families are Gramineae (40 indigenous species), Cyperaceae (25), Euphorbiaceae

(24), Fabaceae (17) and Rubiaceae (11). Due to Bonaire's semi-arid climate the vegetation has an xerophilic character with most plant species having relatively small and often thick, slightly waxy leaves. The relatively harsh conditions also result in the vegetation being relatively low with large trees being scarce and most woodlands not reaching higher than 10 m.

Humans have inhabited and modified Bonaire's habitats for more than 3,600 years (Haviser 2015). In 1520 Spanish conquistadores settled on the island and introduced goats and donkeys, which have had a major impact on the landscape. The Dutch West Indian Company took possession of Bonaire in 1636 and developed a plantation economy. The dry forest was logged for premium timber species, primarily lignum vitae *Guaiacum officinale* and brasil *Haematoxylum brasiletto*, and charcoal production. After the abolition of slavery in 1863, the Dutch government auctioned large parts of the island to private investors, who cleared the land for agricultural production (Stelten & Antczak 2023). In the 1960s, the southern part of the island was developed for large-scale solar salt production (Westermann 1969). The island's economy became increasingly dependent on international tourism (Hartog 1957). Kralendijk expanded to accommodate a rapidly growing human population: from 6,500 people in 1900 to 15,500 in 2010. In 2022 Bonaire had 22,500 inhabitants and annually received around 600,000 tourists (Centraal Bureau voor de Statistiek 2023).

Due to widespread logging for agriculture development most vegetation nowadays consists of secondary growth. The presence of grazers, mostly feral goats, hampers the regrowth of the dry forest. The grazing not only results in a impoverished scrub layer which is more prone to erosion but also favours plants physically adapted to grazing, resulting in vegetations where most plants are adorned with thorns, spines or prickles. A recent mapping of the vegetation resulted in the recognition of 18 different vegetation types

Figure 6. Landscape map of Bonaire (Verweij et al. 2020).

of which only three cover 40 % of the island (De Freitas et al. 2005).

NATURE CONSERVATION

Terrestrial invertebrates on Bonaire are threatened by habitat loss, invasive species, pollution and climate change (Debrot et al. 2018). Urban development poses a threat to dry forest, salinas and the coast line. Native vegetation is often cleared to make way for tourist facilities and residential areas. Overgrazing by feral goats and donkeys prevents dry forest regrowth and restoration. Cats, rats and other invasive predators also have a major impact on terrestrial biodiversity, but there is little quantitative information available on this threat (Wells & Debrot 2008). Sand mining and illegal waste dumping have a detrimental effect on soil and water quality (Raad voor de Rechtshandhaving 2019). Chemical pollution likely forms a major threat to fragile cave systems (Humphreys 2022). Climate change scenarios predict higher temperatures (0.8-1.3 °C) and less rainfall (0-15 %) on Bonaire in 2050. Sea level rise will likely affect the low-lying southern part of the island (Van Dorland et al. 2023).

More than 30% of the terrestrial area of Bonaire, and 100% of its marine area, has a legally protected status. Washington Slagbaai National Park (WSNP), in the northwest of the island, is the oldest protected area in the Dutch Caribbean (Crestian et al. 2022). The park covers 4286 ha, and is managed by Stichting Nationale Parken Bonaire (STINAPA), the national park authority of Bonaire. The nature park and neighbouring Goto Lake are classified as a conservation site of international importance under the Ramsar Convention of Wetlands (site 202). Other Ramsar sites on Bonaire are Klein Bonaire (201), Lac Baai (199) and Pekelmeer (200). The island of Klein Bonaire and the shallow lagoon Lac Baai are part of the Bonaire National Marine Park, also managed by STINAPA (De Meyer et al. 2022). Pekelmeer, which harbours a large breeding colony of American flamingo *Phoenicopterus ruber*, and the surrounding solar salt works, are managed by the US-based company Cargill (Engel et al. 2022). Other areas on the island are classified as nature under the spatial development plan of Bonaire (Ruimtelijk Ordeningsplan Bonaire - ROB). This includes the former plantation Brasil just south of the WSNP, the Middle Terrace and the hill Seru Grandi near Kralendijk.

Particularly the Middle Terrace, which includes the freshwater springs Dos Pos and Fontein, is an area with high biodiversity value (De Freitas & De Lannoy 2013). In principle, these areas are bound to nature conservation rules, and land use is restricted to recreation. In addition, there are several private conservation initiatives to conserve terrestrial habitat on the island, such as the Caves and Karst Nature Reserve, the Sabal Palm Sanctuary, the Tera Barra native garden, the Rooi Lamoenchi Kunuku Park and the San Jose reforestation area.

The Nature and Environmental Policy Plan 2020-2030 (NEPP) specifically aims to conserve and restore key habitats and flagship species in the Caribbean Netherlands (Ministerie van Landbouw, Natuur en Voedselkwaliteit 2020). Activities on Bonaire include the removal of invasive herbivores from WSNP, and the strengthening of the regulatory capacity of the island government. However, the implementation of the environmental legislation and policy continues to be hindered by bureaucratic delays and weak regulatory capacity (Sanders et al. 2019, Inspectie Leefomgeving en Transport 2023).

BIODIVERSITY

According to the Dutch Caribbean Species Register (Dutchcaribbeanspecies.org) slightly less than 3000 species have been recorded from Bonaire of which less than 1200 inhabit terrestrial or freshwater habitats. Despite being near the equator and being surrounded by tropical seas the terrestrial fauna of Bonaire is not mega diverse.
A comparison with the Dutch Wadden island Ameland, which is roughly of the same size, serves to illustrate this (table 1). The relatively low diversity compared with its tropical position is largely explained by the low precipitation and the prolonged dry periods during some years. Aruba, Bonaire and Curaçao form, together with a fringe of coastal Venezuela, a desert-like region more similar in climate to that found in central Mexico. This area is known as the Venezuelan Coast Bioregion (Oneearth.org) and it is likely that this region not only harbours habitats unlike those

Table 1. Comparison of species diversity between Ameland and Bonaire for a selection of relatively well-explored groups. Species recorded as new to Bonaire in this volume are included.

	Bonaire	**Ameland**
Breeding birds	< 60	≈ 100
Mammals	11	≈ 25
Amphibians	3	4
Reptiles	11	1
Vascular plants	< 400	≈ 640
Butterflies	44	34
Dragonflies	11	40
Grasshoppers	23	16
Hoverflies	15	≈ 80
Bees	15	≈ 100
	593	1040

found in the surrounding regions but also holds a unique flora and fauna, with at least some species being endemic to this region.

Probably the best known examples of species restricted to the Venezuelan Coast Bioregion are the Bare-eyed pigeon *Patagioenas corensis* and the Yellow-shouldered amazon *Amazona barbadensis*. The latter is a parrot with a world population of a few thousand of which a large portion is found on Bonaire. The Grasshopper sparrow *Ammodramus savannarum* is represented on Bonaire by the subspecies *caribaeus* (Hartert, 1902). This subspecies is only found on Curaçao and Bonaire and its world population is probably below the 100 breeding pairs with the main breeding site found at the sewage treatment plant to the east of Kralendijk. Given its scarcity and the lack of dedicated protection it is a strong candidate for global extinction. Other examples of animals (largely) restricted to the arid region are the bees *Acamptopoeum colombiense* Shinn, 1965 and *Florilegus flavohirtus* Urban, 1970 and the molluscs *Cerion uva* Linnaeus, 1758 and *Tudora aurantia* (Wood, 1828) (Van Leeuwen et al. 2025, Devalez et al. 2025). It is likely that there are many more examples of species restricted to this area. However, of most species the distribution is insufficiently known making it difficult to be certain that a species is indeed restricted in range. The best example of an insect that is likely restricted to the Venezuelan Coast Bioregion is the recently described butterfly *Burnsius orcynus* Grishin, 2022 which is known from Margarita Island (Venezuela), Curaçao and Bonaire but has not yet been found on mainland Venezuela.

Of the ABC islands both Bonaire and Curaçao have never been connected with the mainland. Aruba is thought to have been connected with mainland Venezuela and as a result some poorly dispersing species do occur on Aruba but are absent from Bonaire and Curaçao. Bonaire is separated from Curaçao by about 40 km of sea and by about 90 km of sea from mainland Venezuela. This will certainly have resulted in the absence on Bonaire of species with a poor dispersal capacity. But an overview of this is lacking. Dispersal from mainland Venezuela to Bonaire is probably facilitated by tropical storms. Indication of this happening in at least dragonflies is provided by Paulson et al. (2014) based on a study on Curaçao in the years 2011-2013. In November 2010, just prior to the study, the tropical storm Tomas dropped 26.5 cm of rain in a single day, nearly half of the average precipitation. At least seven of the 21 recorded dragonfly species were only encountered in the first year after the storm suggesting that they colonised the island during or just after the storm and vanished again after the desiccation of water bodies. It is likely that these tropical storms are followed by mass migration of not only dragonflies but by all kinds of insect species, some of which might temporarily colonise the islands. A more steady flow of entomological observations would be needed to get better data on the relevance of these relatively rare influx events.

One of the main threats to biodiversity on the ABC islands are invasive alien species. An inventory of invasive alien species known from the Dutch Caribbean islands yielded a list of 211 species, including 27 marine species, 65 introduced terrestrial plants and 112 introduced terrestrial and freshwater animals (including agricultural pests and diseases) and seven fungi and plant viruses (Debrot et al. 2011, Van Buurt & Debrot 2011, 2012, Van der Burg & Lap 2012). The list of terrestrial and freshwater animals contains a surprisingly high portion of vertebrates (59 of the 112 species) which is partially explained by the lack of research on invertebrates. Of the species listed two have reached the Caribbean area from Africa by natural dispersal and should therefore not be regarded as invasive alien species (Vagrant emperor *Anax ephippiger* and Cattle egret *Bubulcus ibis)*.

Table 2 lists the invasive alien invertebrates (terrestrial and freshwater) known from Bonaire. This list includes 15 species already listed by Van

Table 2. Overview of invasive alien terrestrial and freshwater invertebrate species recorded from Bonaire.

Group	Scientific name	Common name	Reference
Heteroptera, true bugs	*Corisella edulis*		Chen et al. 2025
Heteroptera, true bugs	*Spilostethus pandurus*		Speelman et al. 2025
Dermaptera, earwig	*Anisolabis maritima*		Willemse et al. 2025
Dermaptera, earwig	*Euborellia annulipes*		Willemse et al. 2025
Blattodea, cockroaches	*Blatella germanica*	German cockroach	Van Buurt & Debrot 2012b
Blattodea, cockroaches	*Periplaneta americana*	Palmetto bug	Van Buurt & Debrot 2012b, Willemse et al. 2025
Blattodea, cockroaches	*Pycnoscelus surinamensis*		Willemse et al. 2025
Blattodea, cockroaches	*Supella longipalpa*		Willemse et al. 2025
Blattodea, cockroaches	*Symploce pallens*		Willemse et al. 2025
Anthophila, bees	*Apis mellifera*		Devalez et al. 2025, Van Buurt & Debrot 2012a
Anthophila, bees	*Megachile concinna*		Devalez et al. 2025
Formicidae, ants	*Cardiocondyla emeryi*		Boer & Wetterer 2025
Formicidae, ants	*Cardiocondyla mauritanica*		Boer & Wetterer 2025
Formicidae, ants	*Hypoponera ergatandria*		Boer & Wetterer 2025
Formicidae, ants	*Monomorium floricola*	Flower ant	Van Buurt & Debrot 2012b, Boer & Wetterer 2025
Formicidae, ants	*Paratrechina longicornis*	Longhorn crazy ant	Van Buurt & Debrot 2012b, Boer & Wetterer 2025
Formicidae, ants	*Pheidole megacephala*		Boer & Wetterer 2025
Formicidae, ants	*Solenopsis geminata*	Tropical fire ant	Van Buurt & Debrot 2012b
Formicidae, ants	*Strumigenys emmae*		Boer & Wetterer 2025
Formicidae, ants	*Strumigenys membranifera*		Boer & Wetterer 2025
Formicidae, ants	*Syllophopsis subcoeca*		Boer & Wetterer 2025
Formicidae, ants	*Tapinoma melanocephalum*	Ghost ant	Van Buurt & Debrot 2012b, Boer & Wetterer 2025
Formicidae, ants	*Tetramorium caldarium*		Boer & Wetterer 2025
Formicidae, ants	*Tetramorium lanuginosum*		Boer & Wetterer 2025
Formicidae, ants	*Tetramorium simillimum*		Boer & Wetterer 2025
Formicidae, ants	*Trichomyrmex destructor*	Destroyer ant	Van Buurt & Debrot 2012b, Boer & Wetterer 2025
Formicidae, ants	*Wasmannia auropunctata*	Little fire ant	Van Buurt & Debrot 2012b
Culicidae, mosquitos	*Aedes aegypti*	Yellow fever mosquito	Van Buurt & Debrot 2012b, Smit et al. 2025
Culicidae, mosquitos	*Culex quinquefasciatus*		Smit et al. 2025
Calliphoridae, blowflies	*Chrysomya megacephala*		Smit et al. 2025
Psychodidae, moth flies	*Clogmia albipunctata*		Smit et al. 2025
Lepidoptera, moths	*Phyllocnistis citrella*	Citrus miner	Van Buurt & Debrot 2012b
Araneae, spiders	*Menemerus bivittatus*		IJland & Verhoogt 2025
Araneae, spiders	*Modisimus culicinus*		IJland & Verhoogt 2025
Araneae, spiders	*Tetragnatha nitens*		IJland & Verhoogt 2025
Acari, mites	*Schizotetranychus hindustanicus*	Citrus hindu mite	Van Buurt & Debrot 2012b
Mollusca, molluscs	*Allopeas gracile*	Graceful awlsnail	Van Leeuwen et al. 2025
Mollusca, molluscs	*Gulella bicolor*	Two-tone gulella	Van Leeuwen et al. 2025
Mollusca, molluscs	*Hawaiia minuscula*	Minute gem snail	Van Leeuwen et al. 2025
Mollusca, molluscs	*Lissachatina fulica*	Giant African snail	Van Leeuwen et al. 2025
Mollusca, molluscs	*Melanoides tuberculata*	Red rimmed melania	Van Leeuwen et al. 2025
Mollusca, molluscs	*Paropeas achatinaceum*	Indonesian awlsnail	Van Leeuwen et al. 2025
Mollusca, molluscs	*Physella acuta*	Acute bladder snail	Van Leeuwen et al. 2025
Mollusca, molluscs	*Planorbella duryi*	Seminole ram's-horn	Van Leeuwen et al. 2025

Mollusca, molluscs	*Polygyra cereolus*	Southern flatcoil	Van Leeuwen et al. 2025
Mollusca, molluscs	*Praticolella griseola*	Vagrant scrubsnail	Van Leeuwen et al. 2025
Mollusca, molluscs	*Streptartemon glaber*		Van Leeuwen et al. 2025
Mollusca, molluscs	*Subulina octona*	Miniature awlsnail	Van Leeuwen et al. 2025
Mollusca, molluscs	*Succinea concordialis*	spotted ambersnail	Van Leeuwen et al. 2025
Mollusca, molluscs	*Veronicellidae indet.*	Leatherleaf slug	Van Leeuwen et al. 2025
Mollusca, molluscs	*Zachrysia provisoria*	Cuban brown snail	Van Leeuwen et al. 2025
Lumbricina, earthworms	*Dichogaster bolaui*		Van Buurt & Debrot 2012a
Lumbricina, earthworms	*Polypheretima elongata*		Van Buurt & Debrot 2012a
Lumbricina, earthworms	*Pontodrilus litoralis*		Van Buurt & Debrot 2012a
Geoplanidae, flat worms	*Platydemus manokwari*	New Guinea flatworm	De Waart et al. 2025

Buurt & Debrot (2011, 2012) and an additional 40 species found as a result of the Bonaire Estafette Expeditie. The list of newly recorded species includes at least two that are of major concern for biodiversity and human health: New Guinean flatworm *Platydemus manokwari* and Giant African land snail *Lissachatina fulica* (De Waart & Van Leeuwen 2025, Van Leeuwen et al. 2025). Of the invasive alien species found new to Bonaire most are found in built up areas suggesting that they cannot survive in more natural habitats. Ornamental (potted) plants seem to be the main source of introduction. Stimulating horticulture on Bonaire itself and reducing the import of ornamental plants therefore would be an appropriate measure to reduce the introduction of new invasive aliens.

BONAIRE ESTAFETTE EXPEDITIE

The Bonaire Estafette Expeditie (Bonaire Relay Expedition), further abbreviated as BEE, took place from 8 October 2022 to 2 March 2023. The research was conducted under research permit 031-22 CNB provided by the Commissie Natuurbeheer Bonaire. In total 25 specialists divided over 12 groups of 2 to 4 persons participated in the fieldwork with most groups staying for a period of two weeks. Each group had a car and the field station of STINAPA at their disposal. The rough roads of the Washington Slagbaai National Park combined with the extensive downpours made it necessary to use a sturdy four-wheel drive (fig. 7). The field station Kas Sientífiko is part of the complex of buildings at the entrance of the Washington Slagbaai National Park. The field station itself has electricity, a kitchen, two sleeping rooms accommodating four persons, wifi and a

Figure 7. Coastal plain at the northeast side of the Washington Slagbaai National Park. Photo Vincent Kalkman.

Figure 8. Landscape at Washington Slagbaai National Park including the buildings at the entrance of the park. The building in front is the Kas Sientífiko. Photo Michiel Boeken.

work table and formed an enjoyable accommodation for the fieldwork (fig. 8).
Table 3 shows the line-up of specialists visiting the field station and their main subject of study. Most specialists mainly focussed on one or several taxonomic groups but nearly all did also collect some data of other groups, either by submitting records to Observation.org or by collecting material for other specialists.

During the expedition one malaise trap was used (table 4, fig. 9-10, 15). Material was collected on alcohol and was sorted and distributed together with standardised labels to various experts by Theo Peeters. The amount of material collected was relatively low but did contain numerous species, mainly of Diptera and Hymenoptera, not collected with other methods.

Figure 9. Malaise trap at Tera Barra. Photo Wim Klein.

Table 5 contains an overview of pitfall traps used. Relatively few habitats have a well-developed detritus layer and the abundance of invertebrates living on the soil-surface is relatively low. Therefore the abundance of both species and specimens in the pitfall traps was relatively low although their use did result in valuable data on the presence of mainly ground beetles and ants. Pan traps were mainly used by groups 2, 5 and 10 and mainly contributed to the records of Hymenoptera and to a lesser extent Diptera.

Collecting on light was mostly restricted to the field station (fig. 11). Most groups of specialists did put the light on every evening. However, collecting of the specimens attracted to the light was done to a varying degree with all specialists collecting the groups of their own interest and most specialists making images and placing them on Observation.org. More or less systematic collecting of moths was restricted to groups 2, 6, 8, 10 and 12. Additional collecting on light was done at Tera Barra.

In general the weather was good and did not limit collecting activities. However, prior to the onset of the rains (end of October) the vegetation was very dry, reducing insect activity. The first half of November was especially wet, with for instance 100 mm rain in the night from 7 to 8 November.

Table 3. Participants of the Bonaire Estafette Expeditie, period of fieldwork and their taxonomical focus of fieldwork.

Group	Start	End	Participants (main focus of fieldwork)
1	8.x.2022	23.x.2022	Berend Aukema (Heteroptera), Dik Hermes (Heteropterea)
2	22.x.2022	6.xi.2022	Wim Klein (Aculeata), Theo Peeters (Hymenoptera)
3	5.xi.2022	20.xi.2022	Marco de Haas (Auchenorrhyncha), Micha d'Oliveira (Diptera)
4	19.xi.2022	1.xii.2022	Roy Kleukers, Baudewijn Odé, Luc Willemse (Orthoptera, Blattodea, Dermaptera)
5	30.xi.2022	15.xii.2022	Jelle Devalez (Antophila), Jordy van der Beek (Diptera)
6	14.xii.2022	25.xii.2022	Vincent Kalkman (Heteroptera), Oscar Vorst (Coleoptera)
7	26.xii.2022	6.i.2023	Vincent Kalkman (Heteroptera)
8	2.i.2023	22.i.2023	Jan-Joost Mekkes (Lepidoptera), Michiel Boeken (general entomology)
9	21.i.2023	5.ii.2023	Hannco Bakker, Tello Neckheim, Sylvia van Leeuwen, Bart van Tooren (Mollusca)
10	4.ii.2023	19.ii.2023	Aglaia Bouma, Jan Wieringa (general entomology)
11	18.ii.2023	26.ii.2023	Tjomme Fernhout (Apidae), John Smit (Diptera)
12	25.ii.2023	11.iii.2023	Frans Groenen, Maria van Eyken (Lepidoptera)

These unusual intensive rains led to flooding. Several roads in the Washington Slagbaai National Park were partly washed away for which reason the park closed for a part of November.

Figure 12 shows the distribution of records collected during the BEE available on Observation.org. Most visiting groups tried to cover the whole island but tended to focus on the easily accessible sites in the direct vicinity of roads or parking lots. Therefore, most regions of the island and most types of habitats were visited while at the same time large areas remained unstudied. Areas where fieldwork was largely limited to the direct vicinity of roads include the Solar Salt work in the south of the island (not accessible), areas to the southeast of Kralendijk, to the northeast of Kralendijk and between Kralendijk and Rincon. Figure 12 also shows that the fieldwork effort in the WSNP concentrated on the areas close to roads.

Some areas were visited often and by most groups, often due to a combination of being accessible and containing interesting or relative rare habitats. These include the direct surroundings of Kas Sientífiko, Playa Chikitu (fig. 13), the Lagadishi trail, Pos Mangel, Put Bronswinkel, some ruderal fields at Rincon (fig. 14), Tera Barra

Figure 10. Locations where the malaise trap was deployed (table 4).

Table 4. Locations of malaise trap (26.x.2022 to 7.iii.2023).

Label	Location	Latlong	Period	Leg
BON.2022-2023.1	WSNP, Lagadishi trail	12.2726 -68.3472	26.x-31.x.2022	Klein & Peeters
BON.2022-2023.2	Tera Barra	12.2118 -68.2784	1.xi- 6.xi.2022	Klein & Peeters
BON.2022-2023.3	Tera Barra	12.2118 -68.2784	6.xi-13.xi.2022	D'Oliveira & De Haas
BON.2022-2023.4	WSNP, Put Bronswinkel	12.280 -68.398	14.xi-21.xi.2022	Kleukers, Odé & Willemse
BON.2022-2023.5	WSNP, Put Bronswinkel	12.280 -68.398	21.xi-28.xi.2022	Kleukers, Odé & Willemse
BON.2022-2023.6	WSNP, Put Bronswinkel	12.280 -68.398	28.xi-5.xii.2022	Van der Beek & Devalez
BON.2022-2023.7	WSNP, Put Bronswinkel	12.280 -68.398	5.xii-12.xii.2022	Van der Beek & Devalez
BON.2022-2023.8	WSNP, Playa Chikitu	12.2791 -68.3485	12.xii-19.xii.2022	Vorst & Kalkman
BON.2022-2023.9	road N BOPEC	12.2264 -68.3814	19.xii-27.xii.2022	Kalkman
BON.2022-2023.10	road N BOPEC	12.2264 -68.3814	27.xii.2022 - 2.i.2023	Kalkman
BON.2022-2023.11	Pos Mangel	12.2950 -68.3919	4.i-7.i.2023	Mekkes & Boeken
BON.2022-2023.12	Pos Mangel	12.2950 -68.3919	7.i-13.i.2023	Mekkes & Boeken
BON.2022-2023.13	Pos Mangel	12.2950 -68.3919	13.i-19.i.2023	Mekkes & Boeken
BON.2022-2023.14	Pos Gurubu	12.1932 -68.2626	20.i-26.i.2023	Van Leeuwen & Van Tooren
BON.2022-2023.15	Pos Gurubu	12.1932 -68.2626	26.i-2.ii.2023	Van Leeuwen, Van Tooren & Bakker
BON.2022-2023.16	Wayaka trail	12.2000 -68.2895	6.ii-11.ii.2023	Bouma & Wieringa
BON.2022-2023.18	Wayaka trail	12.2010 -68.2940	20.ii-23.ii.2023	Smit & Fernhout
BON.2022-2023.19	Rincon, Dos Pos	12.2388 -68.3557	23.ii-27.ii.2023	Smit & Fernhout
BON.2022-2023.20	WSNP, Lagadishi	12.2723 -68.3474	26.ii-2.iii.2023	F. & M. Groenen
BON.2022-2023.21	Rincon, Dos Pos	12.2388 -68.3557	2.iii- 7.iii.2023	F. & M. Groenen

(fig. 15) and Wayaka trail, Lac Baai, the surrounding of the sewage treatment plant to the east of Kralendijk (fig. 16). Most visiting groups made a day trip to the island Klein Bonaire. As the boats to Klein Bonaire land at the beach on the north-side most visits were restricted to this part of the island. For safety reasons, caves were not explored.

Most of the Washington Slagbaai National Park consists of dry low vegetation (fig. 7) or dry vegetation often dominated by columnar cacti (fig. 8). Collecting insects in these areas proved difficult as the densities are low, the thorns restrict the use of a sweeping net and the dry rocky soil makes searching for ground dwelling insects difficult. Most specialists admitted afterwards that they spent less time in the national park then they had anticipated as collecting insects in slightly disturbed habitats outside the park was often easier and more productive. Due to this relatively many observations were made in ruderal fields in Kralendijk, the surrounding of the sewage treatment and Rincon.

RESULTS BEE

Table 6 provides an overview of papers in which material collected during the Bonaire Estafette Expeditie is brought on record. For the groups for which results have been published the BEE on average resulted in a four-fold increase of the number of species known from the island. We expect that in addition a dozen or more papers will appear in the next two to three years, including numerous additional species and several descriptions of species new to science. It must be noted that not for all taxonomic groups publications have appeared and no new overview is available for relatively popular groups as butterflies

and dragonflies. Also in a few cases, such as true bugs and cicadas, many additional species have already been collected and identified but await formal publication. Many of the species brought on record in the publications listed in table 6 have only been identified to genus level. This reflects both the lack of identification literature and the presence of many undescribed species.

Within two years after the end of the fieldwork nearly all of the collected material has been labelled and identified. In addition, most of the material has been published with records being publicly available through GBIF. All this is the result of the dedication of the volunteer experts involved and the efficient cooperation with the curators of Naturalis Biodiversity Center. The material collected during the expedition will be housed at Naturalis Biodiversity Center but some collections are currently still being studied by the involved experts.

Figure 11. Collecting insects at light at Kas Sientífiko. Photo Wim Klein.

FUTURE WORK

The current issue on the results of BEE results in a strong increase of the number of species known to occur on Bonaire but also serves to highlight the lack of knowledge regarding the invertebrates, with many species only identified to genus level.

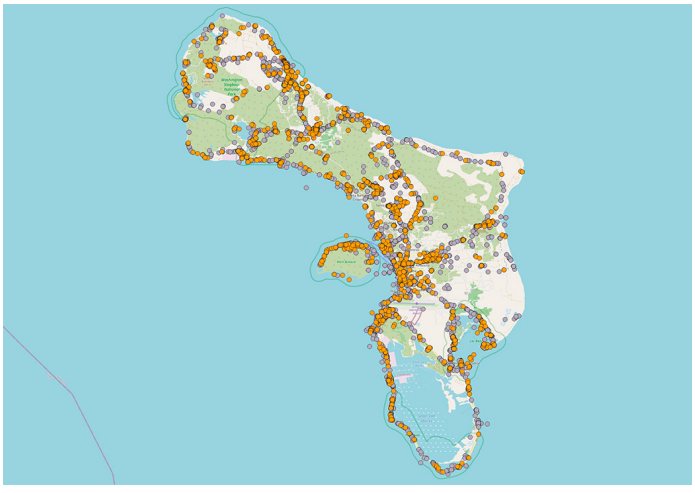

Figure 12. All locations visited during the Bonaire Estafette Expeditie based on data submitted to Observation.org. Grey dots: only records of non-invertebrates, orange dots: records of invertebrates.

Table 5. Locations of pitfall traps (4.I.2023 to 18.II.2023).

Label	Locations	Latlong	Period	Leg	Bait	N	Habitat
BON.2022-2023.31	WSNP, Lagadishi Trail	12.2711 -68.3483	4-19.I.2023	Boeken	none	5	cactus & Acacia bush
BON.2022-2023.32	WSNP, Playa Chikitu mangrove	12.2788 -68.3488	4-19.I.2023	Boeken	none	5	mangrove
BON.2022-2023.33	WSNP, Playa Chikitu dunes	12.2794 -68.3485	4-19.I.2023	Boeken	none	5	dunes
BON.2022-2023.34	WSNP, Pos Mangel	12.2950 -68.3919	4-19.I.2023	Boeken	none	5	moist forest
BON.2022-2023.35	WSNP, Put Bronswinkel	12.2718 -68.3480	4-19.I.2023	Boeken	none	3	moist forest
BON.2022-2023.36	WSNP, Kas Sientífiko	12.2695 -68.3464	4-19.I.2023	Boeken	none	4	ruderal field
BON.2022-2023.37	Tera Barra dam	12.2114 -68.2784	6-19.I.2023	Boeken	none	4	natural regrowth
BON.2022-2023.38	Tera Barra Caracara	12.2115 -68.2784	6-19.I.2023	Boeken	none	2	natural regrowth
BON.2022-2023.39	Tera Barra pond	12.2115 -68.2785	6-19.I.2023	Boeken	none	3	natural regrowth
BON.2022-2023.40	Tera Barra compost	12.2108 -68.2784	6-19.I.2023	Boeken	none	2	near compost heap
BON.2022-2023.41	Dam Grandi	12.2607 -68.3386	6-19.I.2023	Boeken	none	5	bank side vegetation & dyke
BON.2022-2023.42	WSNP, Kas Sientífiko	12.2695 -68.3464	7-19.I.2023	Boeken	meat	1	ruderal field
BON.2022-2023.43	wsnp, Pos Mangel	12.2950 -68.3919	7-19.I.2023	Boeken	meat	1	moist forest
BON.2022-2023.44	Wayaka trail	12.2000 -68.2895	6-18.II.2023	Bouma & Wieringa	none	2	dry plateaux
BON.2022-2023.45	Playa Chikitu	12.2805 -68.3486	6-17.II.2023	Bouma & Wieringa	none	2	dunes
BON.2022-2023.46	North of Kralendijk	12.1829 -68.2944	7-18.II.2023	Bouma & Wieringa	none	1	slope near mangrove
BON.2022-2023.47	WSNP	12.2845 -68.3824	10-17.II.2023	Bouma & Wieringa	none	2	small brook
BON.2022-2023.48	Near office STINAPA	12.2019 -68.3078	13.II.2023 18.II.2023	Bouma & Wieringa	meat	1	batcave
BON.2022-2023.49	Near office STINAPA	12.2019 -68.3078	13-18.II.2023	Bouma & Wieringa	fruit	1	batcave
BON.2022-2023.50	NE point of Bonaire	12.2185 -68.2158	13-18.II.2023	Bouma & Wieringa	meat	1	batcave
BON.2022-2023.50	NE point of Bonaire	12.2185 -68.2158	13-18.II.2023	Bouma & Wieringa	fruit	1	batcave

Figure 13. Dunes at Playa Chikitu. Photo Vincent Kalkman.

Further work on the material collected during the BEE is needed as well as additional fieldwork on Bonaire and the other ABC islands. Information on identification of most of the species groups is limited and keys and field guides are needed in order to facilitate the work of, for instance, students. Two topics which deserve attention are the phenology of insects in relation with the dry and wet season and the impact of the removal of goats on the insect fauna.

Groups like woodlice (Isopoda), centipedes (Chilopoda), millipedes (Diplopoda), springtails (Collembola), mites (Acari) have not been studied. Most of these groups are ground dwelling and are more species rich in areas that are moist throughout the year and have a well-developed detritus layer. For this reason these groups probably have relatively low diversity on Aruba, Bonaire and Curaçao. Biospeleological fieldwork on Aruba and Curaçao in 1985 resulted in the discovery of various cave-dwelling arthropods, including beetles new to science (Colijn et al. 2019). It is likely that fieldwork in the caves on Bonaire would result in

Figure 14. Ruderal vegetation at Rincon, Kaya Lelu. Photo Wim Klein.

Table 6. Publications in which material collected during the Bonaire Estafette Expeditie was used. * For true bugs (Heteroptera) and cicadas (Auchenorrhyncha) only a part of the material has been identified and published and for both groups at least 50 additional species still need to be formally reported from Bonaire.

Taxonomic group studied during BEE	Number of species prior to BEE	Updated number of species	Publication
Heteroptera*	38	48	Chen et al. 2025, Nieser et al. 2024, Speelman et al. 2025
Auchenorrhyncha*	1	2	De Haas & Gaiani 2024
Orthoptera	6	23	Willemse et al. 2025
Blattodea	4	7	Willemse et al. 2025
Dermaptera	1	2	Willemse et al. 2025
Hymenoptera: Vespidae	1	3	Klein 2025a
Hymenoptera: Spheciformes	1	19	Klein 2025b
Hymenoptera: Anthophila	1	15	Devalez et al. 2025
Hymenoptera: Pompilidae	0	4	Bouma et al. 2025
Hymenoptera: Formicidae	10	53	Boer & Wetterer 2025
Hymenoptera: Parasitica	1	29	Peeters et al. 2025
Coleoptera	42	242	Vorst et al. 2025, Felix et al. 2025
Diptera	9	94	Ebejer 2024, Van der Beek et al. 2024, Oosterbroek et al. 2024, Smit et al. 2025
Lepidoptera (moths)	4	147	Groenen 2025
Araneae	27	47	IJland & Verhoogt 2025
Acari: Hydrachnidia	1	1	Smit 2025
Mollusca (terrestrial & freshwater)	20	37	Van Leeuwen et al. 2025
Crustacea: Anostraca	1	2	Soesbergen & Jansen 2025
Platyhelminthes, Geoplanidae	0	1	De Waart et al. 2025
Charales (stoneworts)	5	6	Van Tooren & Bruinsma 2024
Desmids	0	35	Van Tooren et al. 2024
Total	173	817	

the discovery of a similar diversity of cave dependent species.

As noted above, fieldwork is hampered by the lack of easily accessible field guides. Developing a guide to the butterflies, dragonflies and grasshoppers of the ABC islands as well as the further development of the Caribbean image recognition model are therefore priorities for future work.

Figure 15. Malaise trap at Tera Barra. Photo Wim Klein.

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Figure 16. Ruderal vegetation in the surroundings of the sewage treatment plant to the east of Kralendijk. Photo Vincent Kalkman.

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SAMENVATTING

Bonaire Estafette Expeditie, een inventarisatie van de terrestrische ongewervelde dieren van Bonaire

Dit artikel vormt de inleiding op een speciale editie van Nederlandse Faunistische Mededelingen, met daarin 21 artikelen over het voorkomen van ongewervelden in Caribisch Nederland. Het artikel geeft informatie over het landschap en de biodiversiteit van Caribisch Nederland met nadruk op Bonaire, beschrijft de Bonaire Estafette Expeditie, vat de resultaten samen en geeft een overzicht van de tot nu toe verschenen artikelen. De meeste van deze artikelen zijn gebaseerd op materiaal verzameld tijdens de Bonaire Estafette Expeditie (BEE) (8 oktober 2022 tot 2 maart 2023). Tijdens deze expeditie hebben 25 experts veldwerk verricht aan een groot aantal terrestrische en zoetwatergroepen. De mariene fauna van Caribisch Nederland is relatief goed onderzocht maar het overzicht van de ongewervelde dieren van zoet water en terrestrische biotopen is zeer onvolledig. Het materiaal dat hier gepubliceerd wordt bevat meer dan 600 soorten die voor het eerst van Bonaire vermeld worden. Veel daarvan zijn nieuw voor Caribisch Nederland. In veel gevallen was het niet mogelijk om het materiaal tot op soort te determineren, deels omdat determinatieliteratuur ontbreekt maar eveneens doordat vermoedelijk vele tientallen soorten nieuw zijn voor de wetenschap. Onder de nieuw op Bonaire aangetroffen soorten bevinden zich 43 niet-inheemse ongewervelden waarmee het aantal exoten voor Bonaire op 56 komt. Hieronder bevinden zich twee soorten die een probleem vormen voor de gezondheid en biodiversiteit: de Nieuw-Guinese landplatworm *Platydemus manokwari* en de grote agaatslak *Lissachatina fulica*.

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